

PRESERVATION OF CATTLE HIDES WITH POTASSIUM CHLORIDE*

by

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ABSTRACT

Research was conducted to evaluate the effectiveness of Potassium chloride (KCl) as an alternative to sodium chloride (NaCl) for the preservation of cattle hides. The incentive for this research is that concentrated KCl solutions do not cause the environmental problems that are associated with saturated brine. Excess KCl brine from a curing raceway can be applied directly to the soil as a fertilizer providing potassium, a necessary plant macro nutrient. While KCl is more expensive than salt on a pound for pound basis the savings in brine disposal in some situations will more than make up the difference. On a laboratory scale we have demonstrated that cattle hide samples soaked in concentrated solutions of KCl and drained of excess moisture appeared to be well preserved after six months. A matched side study of KCl cured hides vs. NaCl cured hides was conducted in which the sides were stored for forty days before tanning. No significant differences were observed in two different lines of leather manufactured from these hides.

INTRODUCTION

Effluent sodium chloride (NaCl) content is a major concern for the meat packer, the hide processor and to a lesser extent the tanner. Salt is one of the most difficult components of an effluent to treat. The only cost effective way to remove dissolved solids from an effluent is to avoid putting them in in the first place. Finding a cost effective means of

eliminating NaCl from the effluent of hide processor is the primary incentive for conducting this research.

Potassium chloride (KCl), one of several salts of potassium commonly referred to as potash, has quite different properties from NaCl. It is a plant macro nutrient used in large quantities for fertilizer in North America. If KCl brines could preserve cattle hides as well as NaCl then excess KCl brine could be land applied in almost limitless amounts as a fertilizer. This would totally avoid the problems of salt pollution arising from the curing of cattle hides with NaCl.

Preservation of food with NaCl, like the tanning of animal hides for clothing and shelter, predates written history. And while it is very likely that over the years many individuals have tried using potash as an alternative to NaCl to preserve hides and skins very few have published any information on the results. Two exceptions were revealed in a literature search, one a Russian patent¹ and the other a Japanese paper². These papers refer to KCl only as one of a series of salts investigated for hide and skin preservation but no information was given relative to the production of leather manufactured from these hides or skins.

There has been a lot of research in the food industry to produce low sodium foods by substitution of NaCl with KCl^{3,4}. However, high concentrations of potassium impart a metallic taste to food that prevents it from being a total replacement for food use. The originator of the idea, to use potash to preserve cattle hides, that led to this research, was Pat Gummeson, Production Manager at Lakeside Packers, Ltd., Brooks, Alberta. After soaking a section of cattle hide in potash (KCl) solution overnight and allowing it to drain, he sent it to a tanner to be made into leather. The tanner observed no difference in the leather produced from the

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hide piece and the brine rawstock that was normally processed.

Lakeside Packers then contacted Kalium of Canada, one of the world's largest potash producers, to follow up on the use of KCl for hide preservation. Kalium decided to further investigate the original observation and assigned Joe Gosselin, Senior Chemist, to head up an investigation.

As a result, a cooperative venture was initiated under a Memorandum of Understanding (MOU) to perform the research between the Hides, Lipids, and Wool Research Unit of the Agricultural Research Service and Kalium of Canada. The results of a portion of the research performed under this MOU and a discussion of some of the advantages and disadvantages of KCl over NaCl for curing cattle hides are the subject of this publication.

It is important to repeat that the practical incentive for pursuing this work is that KCl is a plant macro-nutrient. Kalium** alone sells over two million tons a year of KCl to the North American agricultural community for fertilizer. This suggests that the KCl brine produced in a KCl brine raceway could be readily disposed of by land application. Potentially it could even be marketed locally as a fertilizer, a distinct advantage over a NaCl brine.

With this as the incentive to do the research there were two obvious questions that needed to be answered. The first is what effect does KCl have on the normal bacterial populations found on fresh hides and second, what effect does KCl curing of cattle hides have on leather quality?

MATERIALS AND METHODS

THE INITIAL LABORATORY SCALE EXPERIMENT

One hundred eight three-inch diameter circles were cut from a fresh steer hide. Four liters of three different concentrations (3M, 4M and 5M) of laboratory grade KCl were prepared. Thirty six samples were placed into each solution. After soaking the hide samples for three days (approximately 60 hours) at room temperature, with only occasional stirring, the 36 pieces from each different soak solution were removed, drained of excess moisture and further separated into three groups of twelve. Each group was placed in a plastic bag and stored at either 40°F (4°C), 70°F (21°C) or 106°F (41°C). After 5 months the samples were removed

from storage, the appearance and odor noted and bacterial counts made. Moisture and salt analysis were performed on each sample and the molar salt concentration of KCl within the moisture in the hide was calculated⁵. Bacterial counts were made by removing approximately 1 cm diameter plugs from each sample, extracting them with 4M KCl in a 0.1% peptone solution and plating various dilutions on plate count agar (PCA) and PCA containing 4 M KCl.

PILOT PLANT SCALE TANNING EXPERIMENTS

Three fresh cattle hides were sided and each side was further divided into four approximately equal segments. Twelve segments were separated from one side of the backbone and cured overnight in 4 Molar commercial grade KCl supplied by Kalium of Canada. Matching segments from opposite sides of the backbone were NaCl-cured. Leather was prepared in our pilot plant tannery from two matched pairs of segments two weeks after curing. The standard USDA tanning procedure was used⁶. Four sections consisting of two matched pairs were to be tanned every two weeks out to a total of three months.

INDUSTRIAL SCALE TANNING EXPERIMENT

A one hundred hide matched side experiment was conducted comparing leather prepared from NaCl cured sides with KCl cured hides. Curing was carried out at Lakeside Packers, Ltd. in Brooks, Alberta.

The curing process began by soaking fresh hides directly from the kill floor in a 16,800 gallon paddle for two hours in 110°F water. This water in the paddle came directly from the beef wash portion of the packing plant. After soaking, each hide was fleshed and sided. Each side was individually marked using a system of punched holes that could later be used to identify each side. Alternating right and left sides were either NaCl brine cured in the Lakeside commercial brine raceway or KCl brine cured in the paddle. Brine curing was done to 85% or better saturation of the moisture in the hide. Ultimately we were only interested in comparing the physical properties and quality assessments of the left side of each hide with the right side of the same hide. Using matched sides in this kind of experiment helps eliminate bias in the results that might be caused by a small number of poor or good hides. All of the cured hides were processed into leather at Dominion Tanners, Ltd., Winnipeg, Manitoba.

** Mention of brand or firm names does not constitute an endorsement by the U.S. Department of Agriculture over others not mentioned.

RESULTS AND DISCUSSION

THE INITIAL LABORATORY SCALE EXPERIMENT

After five months storage the 4M and 5M KCl treated cattle hide samples held at all three temperatures appeared to be well preserved.

There was no sign of odor or hair slip that would suggest bacterial damage. The samples treated with 3M KCl did not hold up as well. The strong odor and brown exudate draining from the samples held at 106°F were typical of bacterial degradation. The samples held at room temperature appeared to be starting to deteriorate. The 3M treated samples held at 4°F were satisfactory. Analysis of the KCl content of these treated hide samples showed that the final concentration in the hide reflected the treatment molarity. The 2.88 M concentration found in the 3M treated samples was clearly not sufficient to preserve the hides. The small increase in the KCl content of the samples in the 5M treatment over the 4M treatment reflects the limitation of KCl solubility at room temperature of about 4.5 M. These results are summarized in Table I.

PILOT PLANT SCALE TANNING EXPERIMENTS

Since it was clear that 3M KCl was not able to preserve the hide properly, the first experiments to determine the effect of KCl treatment on leather quality were done treating the hides with 4 M KCl. The first pieces of leather from this experiment appeared to be of good quality and no differences were observed between the NaCl cured segments compared to the KCl cured segments. However, after four weeks it was clear that there were bacteria growing on these

KCl treated hide samples. The odor was not bad but microbial growth was clearly visible on the hair surface of the hide samples. Salt and moisture analysis showed that these samples contained only between 2.14 and 2.48 M KCl, a level already shown in the laboratory scale experiments to be insufficient for good preservation.

The low concentration of KCl in the hide turned out to be due to the way the samples were cured. Segments were drummed overnight in a 500% float containing 4M KCl. The drum was rotated only 5 minutes on the hour. It appears that the concentration of KCl in the float in combination with the relatively mild mechanical action was not sufficient to put enough KCl into the hide in an 18 hour treatment.

To test this hypothesis the remaining samples were rerun in the same drum, continuously, overnight in a 4.25 M KCl solution. The measured KCl molarity in the segments increased to greater than 3.85 and no further evidence of bacterial growth was observed up to the time all of the samples were tanned two months later. Even in these samples, in spite of the apparent microbial contamination occurring after one month of storage, no differences were observed in the leather prepared from the NaCl cured and the KCl cured hides.

INDUSTRIAL SCALE TANNING EXPERIMENTS

The conditions used for the industrial trial were based on the results of the pilot scale experiment. The concentration of KCl in the paddle was 4.25 M KCl. We ran into two interesting problems with the scaled up KCl cure. The first was related to the temperature of the bath and the second to the mechanical action of the paddle during the KCl curing.

TABLE I
Potassium Chloride Content and Condition of Experimental
Cattle Hide Samples After Five Months Storage
Condition Based on Odor and Appearance

KC Treatment Concentration	Final KCl in Samples	Storage Temperature		
		40 deg F	70 deg F	106 deg F
3M	2.88 M	Good	Fail	Fail
4M	4.05 M	Good	Good	Good
5M	4.2 M	Good	Good	Good

One physical property difference between KCl and NaCl is their solubility over a range of temperatures (Figure 1). The solubility of NaCl is relatively constant between 0 to 100 F. The solubility of KCl, however, is much more temperature dependent. Another significant physical property of KCl, at least for these experiments, is that it absorbs heat from solution when it is dissolved. This is the same phenomenon used in the chemical cold packs found in first aid kits. In order to make up a 4.25 Molar KCl brine, 22.3 tons of KCl was added to 16,800 gallons of water in the paddle. As the KCl dissolved the temperature in the paddle dropped to 55°F (13°C). This drop in temperature lowered the amount of KCl in solution and a low pressure steam line had to be used to bring the temperature back up to 70°F. This property of KCl does not represent a practical problem because once a raceway is filled and in continuous operation the only KCl that has to be added daily is an amount equal to the KCl removed with the cured hides. This would be a relatively small amount compared to the KCl remaining in the raceway and would have little effect on the temperature of the raceway.

The second problem had to do with the recirculation system for the soak paddles. Under normal operation the vigorous mechanical action of the soak paddle splashed substantial amounts of soak water out of the paddle. This soak water was collected in a sump and continuously recirculated back into the paddle to maintain a high water level. Since only one of the paddles was used in this test for KCl curing the recirculation system could not be used, and as a result the

liquid level in the paddle was reduced by almost 12 inches by the end of the KCl brine cycle. The lowered water level considerably reduced the mechanical action in the paddle. We were concerned that we would not get sufficient KCl into the hide for good preservation. To compensate for the temperature drop and the lower mechanical action the total soak time for the KCl hides was extended to 28 hours. It is not expected that KCl during will take more time than NaCl curing under conditions of proper temperature and mechanical action. Commercial application of KCl curing will require a 24 hour processing turn around and future experiments will be designed to determine the conditions necessary for this to occur.

The NaCl brine cured hides were removed from the brine raceway, pulled through a pair of vertical rollers to squeeze excess moisture out of the hides, and pulled onto a grading table. Safety NaCl salt was added, the sides were then folded and placed on a pallet. The KCl brined hides were handled in the same way except KCl was used as safety salt. Fifty sides were folded, placed on a pallet, hydraulically pressed to remove further moisture, and weighed. There were a total of four pallets.

After five weeks all four pallets were shipped to Dominion Tanners in Winnipeg, Manitoba. Exactly forty days after curing, each side was examined one at a time before being placed in a drum to be soaked, unhaired and limed. The condition of both the KCl and the NaCl cured hides was excellent. The KCl-cured hides were more flaccid and

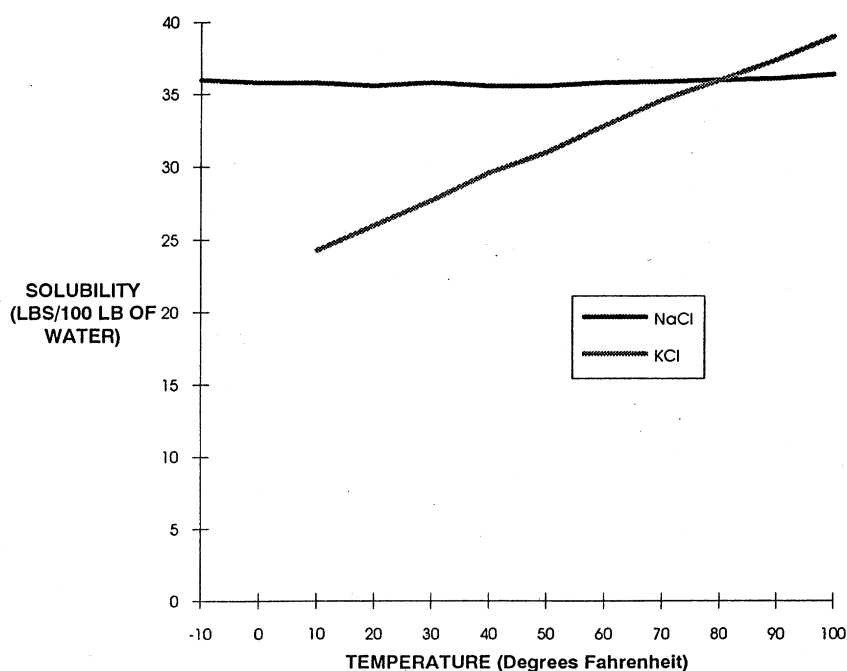


FIGURE 1. — Solubility with temperature curves for NaCl and KCl.

appeared to contain more moisture than the NaCl cured hides. The weights of the four pallets and the average weight of the sides confirm that NaCl brine curing removed more water than the KCl curing (Table II). The moisture content of the KCl-cured hides averaged 48.5% and the brine cured hides averaged 44.0%. There was no hair slip or odor problems in either cure. The edges of the NaCl cured hides were a little more dried out but this may be because the KCl sides were wrapped in plastic during storage and shipping. After liming the sides were fleshed and tanned together in the same drum along with a few additional full hides to make up a full pack.

The normal blue sort was carried out on all two hundred sides after wringing. They were sorted into three grades of heavy and medium weight leather. The results are shown on Table III.

After blue sort each side was measured electronically and graded for break. The area difference was small and not statistically significant (Table IV). There was a slight difference in draw in favor of the KCl-treated sides that might correspond to the fact that less moisture was removed from these hides during curing. Evaluation of the draw on each of the matched pairs showed that 59% of the matched side pairs were identical, 18% of the NaCl-cure sides had less draw than the corresponding KCl opposite side and the reverse was true for 28% of the KCl sides.

After grading into normal selections for blue stock the hides were separated again into the two sets of matched pairs. Half of the matched pairs were processed into a vacuum dried leather product and the other half into a paste dried product.

TABLE II
Pallet and Cattle Side Weights (lbs) After Curing

	NaCl	KCl
Pallet 1	1651 (52)	1692 (50)
Average Side	31.8	33.8
Pallet 2	1480 (47)	1743 (51)
Average Side	31.5	34.2

() Indicates number of sides.

TABLE III
Grade Sort in Blue for KCl and NaCl Cured Cattle Hides

	KCl	NaCl	Total
M#1	0	0	0
M#2	8	4	12
M#3	4	1	5
H#1	12	9	21
H#2	59	57	116
H#3	20	26	46

TABLE IV
Area Comparison of Blue Stock from KCl and NaCl Cured Cattle Hides
This Represents 86 Matched Side Pairs

Cure	Sq. Ft./Side	Std. Dev.
KCl	21.88	1.66
NaCl	21.74	1.55

TABLE V
Tensile Strength of Crust Leather Prepared from Cured Cattle Hides
This Data Represents 86 Matched Side Pairs

Cure	Paste Dried		Vacuum Dried	
	Tensile (psi)	Std. Dev.	Tensile (psi)	Std. Dev.
NaCl	3065	868	3031	626
KCl	3056	743	3123	564

In the crust sort for paste dried leather, seven KCl and one NaCl brine sides were rejected. Most of the rejections were based on scratches in the grain rather than factors that might be related to the salt used for preservation. The sides converted to vacuum dried leather contained 11 NaCl and 10 KCl rejections. Tensile strength was done on the matched sides from both sets of crust⁷. Again the results were not statistically different (Table V).

The primary beneficiary of these results is the meat packer and hide processor. They have the most severe effluent problems as a result of NaCl brine curing and have the most to gain from using KCl as a hide preservative. To take advantage of the KCl cure a tanners soak stream would have to be isolated from the other beamhouse waste streams. While effluent dissolved solids may be a serious problem for certain tanners, for the majority of them it is less important than some of the other environmental issues they face.

While the experimental results of our research are extremely encouraging it is appropriate to discuss several practical considerations that will have an impact on KCl curing operations. Each consideration has to be evaluated carefully before a decision is made to either convert to KCl curing or

to continue to preserve with NaCl. They are the cost of KCl compared to NaCl, the practicality of disposing of the excess KCl brine as fertilizer and the effect of temperature on the solubility of KCl.

KCl costs more than NaCl on a delivered pound for pound basis. The cost will vary greatly, in the same way it does for NaCl, depending on the location of the hide curing operation and the volume consumed. The significance of this cost differential to each processor will depend on how difficult it is to dispose of the NaCl brine now being produced. If, for example, a hide processor can dispose of NaCl brine without surcharge or other additional costs, then NaCl is the cure of choice. However, if a hide processing operation has to construct holding ponds for excess brine and has no other means of brine disposal, then KCl may be an attractive alternative.

The option to use KCl brine as a fertilizer will also depend on location. All plants require potassium for growth but the amount varies greatly depending on the species. Table VI contains typical potassium uptake by a variety of crops during a single growing season. Alfalfa crops are clearly the highest consumers of potassium. Based on the uptake of potassium it can be calculated that a five thousand hide a

TABLE VI
Uptake of Potassium Chloride by Various Crops
lbs/acre/crop

Alfalfa	300
Clover	202
Grass	130
Corn Silage	202
Sugar Beets	386
Potatoes	298
Tubers	216
Vines	82
Peas	137
Wheat	72
Oats	145
Rye	131
Corn	129
Sunflowers	37

day packing plant would require about 15,511 acres of alfalfa to consume one year's production of brine. In areas of North America that have a high natural abundance of KCl in the soil, land disposal of the brine would still be appropriate although it might not be a salable byproduct.

The decreasing solubility of KCl solubility with temperature will have to be considered by hide processors in cold climates. If the concentration of soluble KCl falls much below 4.25 M the amount taken up by the hide may not be high enough to achieve the desired preservation.

CONCLUSIONS

The results from this research demonstrate that the leather produced from cattle hides preserved for almost six weeks in a KCl brine does not differ significantly from cattle hides preserved with NaCl. Longer term preservation still needs to be confirmed for full hides to be certain that a prolonged resistance to microbial deterioration exists. However, 3" diameter samples preserved in the initial small scale experiments were still in excellent condition after 9 months.

ACKNOWLEDGEMENT

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DISCUSSION

Robert Good, Pfister & Vogel: For this to become a standard industrial practice, we are going to have to eventually arrive at the point where we know what an acceptable level of salt concentration in the hides is to preserve them. Perhaps it will become published in the standard industry practice for cattlehide preservation. I would like to pass along a good idea, which is not mine but which is Jean Tancous'; and, that is, the standard method of reporting that the salt concentration in a hide should be based on the hide substance rather than the saturation of the water, since the water can vary and the hide substance does not.

Answer: Yes, You're absolutely right.

Robert Good: Can we expect to see the results in the published reports expressed in that manner?

Answer: I'll give that very serious consideration. We could perhaps add that information in a table, that would not be a problem.

Waldo Kallenberger, LIA Laboratory: It's not a minor thing to do all those Kjeldahl nitrogens.

Robert Good: I don't think you would have to base it on Kjeldahl nitrogens, that would be extreme, you would simply take the ash versus the other solids.

Frank Rutland, LIA Laboratory: Dave, you mentioned that the KCl cure is not quite as astringent as a normal brine raceway cure. Did you in fact observe any differences in traditional brine draw in either half of the matched side experiments?

Answer: We looked for draw and we didn't see any difference. If there was any difference it was in favor of KCl but it was small.

Frank Rutland: I do not know what average moisture level you achieved in the KCl cured hides but this would likely add another element to the cost differential between the two since you could be transporting more water.

Answer: That's correct. There's one other factor here which may eventually come up. Not only can you now use KCl instead of NaCl for curing, KCl apparently works in the pickle. Also, there may be some other potassium salts that you can use in place of sodium salts in the beamhouse. This might make the entire effluent a more land-applicable effluent than it is currently using sodium salts. This may be something beyond this particular paper but it may have an impact on the overall effluent treatment.

Jerry Breiter, USHSLA: Dave, thanks for a very interesting paper. One of the economic sides of this has to do with time. Is there a time difference in the cure for KCl versus NaCl?

Answer: No, our results seem to indicate that if you give the hides good mechanical action and you start at around 4.25 molar KCl, the cure would be equivalent to NaCl.

Leo Devarenne, Wolverine Leathers: I'm assuming when you cure the hides in the raceway with KCl, you use KCl as safety salt. Is that correct?

Answer: That's correct.

Leo Devarenne: Have you looked at a mixer cure where you really wouldn't have any raceway, you just put dry KCl into a mixer?

Answer: No, not yet. Perhaps I did not make it clear. This was not a raceway cure, these hides were cured in a paddle.

Leo Devarenne: Yes, but you still use a solution of KCl.

Answer: That's right. But we are following up this summer with a raceway experiment.

Leo Devarenne: How about a mixer experiment?

Answer: We haven't planned on that but that's a good idea.